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NEW PATENT APPLICATION

IMPROVEMENTS IN THERMAL WELDING

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IMPROVEMENTS IN THERMAL WELDING

BACKGROUND OF THE INVENTION

The present invention relates to thermal welding processes and in particular to methods of cooling workpieces during a thermal welding process.

During the thermal welding of metallic workpieces a high heat input is required to generate an acceptable weld. However, this high heat input has the disadvantage that it can cause significant levels of distortion of the workpieces being welded.

It is known to use gases to provide forced cooling during arc welding processes. However, the results of using cooling gases are limited as the cooling ability of the gas streams is relatively low.

Cryogens, particularly liquid nitrogen, and solid carbon dioxide have been used to provide enhanced cooling to arc welding (i.e. fusion) processes in order to enable high quality welds to be produced rapidly without thermal distortion of the workpieces, workpieces of relatively soft metals and alloys such as aluminium and aluminium alloys being particularly prone to distortion and reduction tensile strength. Fusion welding processes employing such cooling are, for example, described in GB-A-1 552 660; GB-A-0 764 336; WO-A-95/236 69; CN-A-1 110 206; JP-A-04-0 288 991; JP-A-02-0 052 173; JP-A-60-0 033 881; JP-A-60-0 018 292; JP-A-52-0 076 243 and SU-A- 414 066.

A drawback of such use of the cryogenic coolant is that it tends to interfere with the welding arc and therefore to disrupt the welding process. Hence the

prior documents cited above do not solve the problem of the reliable and rapid formation of stress and strain free welds when joining two workpieces.

Friction stir welding is an alternative welding process to electric arc welding. Examples of friction stir welding are disclosed in WO-A-95 26254, US-A-5 460 317 and US-A- 5 813 592. Difficulties still arise however in reliably and rapidly forming stress and strain free welds when joining two workpieces by friction stir welding.

In a friction stir welding process a tool is used which comprises a shank, a body (sometimes with cooling fins), a shoulder and a pin. There are a wide variety of different tool designs. The tool is usually made from tool steel and may have a specialised coating. The tool is inserted into what is, in essence, a milling machine. The pin is lowered onto the two plates to be joined. The rotation of the pin heats the metal until it softens. At this point the pin is pushed downwards so that the shoulder comes into contact with the metal plates. The shoulder has a concave profile so that the tool locates the plasticised metal displaced by the pin. The should now beings to heat a larger volume of the metal. Eventually enough metal is soft enough to allow the pin to be traversed through the metal plates. The pin stirs the plastic metal surrounding it and therefore joins the two plates together. The process then continues with the pin and the shoulder heating the metal so that it is plasticised and the pin stirring the metal plates together.

SUMMARY OF THE INVENTION

According to the present invention a method of friction stir welding together at least two metallic workpieces includes the step of applying at or adjacent to a heated welding zone at least one jet of cryogen.

The cryogen may be in the form of a liquid cryogen, for example, liquid nitrogen or liquid argon. Alternatively, and preferably, the cryogen may be solid carbon dioxide.

Preferably the cryogen is applied to the welding zone through a plurality of nozzles.

In friction stir welding the necessary heat is generated internally by operation of a stirring pin. There is no fusion of the metal rather, at least one of the workpieces is plasticised.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawing in which:

Figure 1 is a sketch of two metallic plates being butt welded together according to the present invention;

Figure 2 is a schematic perspective drawing of butt welding apparatus for use in the method according to the invention; and

Figure 3 is a graph showing the effect of the method according to the invention in reducing longitudinal residual tensile stresses in weld made by a frictional stir welding method.

DETAILED DESCRIPTION OF THE INVENTION

Referring first to Figure 1, two metallic plates 1, 2 to be butt welded together are placed as shown side by side and a stir welding pin 4 is positioned at the abutting surfaces of the two plates. The welding pin 4 is energised in a

manner known per se and as a result of its rotation generates heat in a welding zone along the abutment of the two metal plates. Any of the friction stir welding methods and apparatus disclosed in WO-A- 95/26254, US-A-5 460 317 and US-A- 5 813 592 may be used for this purpose. At the same time a cryogen is applied to the welding zone in the form of two jets 6, 7 which pass respectively through nozzles 8, 9.

The cryogen may be a liquid cryogen for example liquid nitrogen or liquid argon. Alternatively the cryogen could be solid carbon dioxide or a mixture of solid carbon dioxide together with a liquid cryogen.

It has been found that by using a cryogen to cool the metallic components being welded the following effects have been observed:

a) the reduction or control the level of distortion;

b) the reduction of tensile stress;

c) the protection of heat sensitive components near the welding zone;

d) the reduction of the effects of chemical degradation as a result of heat;

e) the control of metallurgical properties (i.e. control of grain growth);

f) more rapid cooling, thereby permitting handling of the workpiece sooner after welding than is conventional methods. This advantage makes possible increases in the overall productivity of a welding shop; and

g) no problem arises in the coolant interfering with the welding process, unlike in arc welding processes.

The choice of the cryogen is dependent on the process and the material of the metallic plates being welded. The amount of cooling and location to which the cryogen is applied is strictly controlled in order to achieve the desired effect. This is achieved by applying the cryogen via a nozzle or nozzles directed on to the surface of the workpieces being welded. The size and geometry of the nozzles is a critical factor for controlling the cooling footprint as well as the location and orientation of the cooling jets.

Example

Referring to Figure 2 of the drawings, a butt joint of two aluminium alloy plates 20, each 6.35 mm thick, was made by friction stir welding employing a friction stir welding tool 22. A jet of solid carbon dioxide particles was applied on the top side of the weld from a nozzle 24. The point of application of the carbon dioxide was arranged to trail the welding point by approximately 20 mm. The vertical stand off distance between the tip of the nozzle 24 and the weld was 20mm. The nozzle 24 had a diameter of 1 mm. The jet of solid carbon dioxide particles was formed conventionally (for example by causing a pressurised liquid stream of carbon dioxide to flow from a source (not shown) thereof via solenoid valve 26 through the nozzle 24). The carbon dioxide was supplied at a rate of 1.5 kg/min and at a supply pressure of 22 bar. The friction stir welding tool 22 was rotated at a speed of 355 revolutions per minute and was translated at 95.2 mm per minute.

Residual stress measurements by neutron scattering methods made longitudinally through the finished weld clearly show the advantageous effect of cryogenic cooling on stresses in the central weld zone. Figure 3 shows the difference between weld samples made with and without cryogenic cooling in accordance with the invention. Figure 3 shows a substantial reduction in the tensile stresses in the weld zone. In addition the cooling actually created

compressive stresses in this area. Creation of such compressive stresses is recognised in the art as a highly desirable feature.